Digital Technologies in Primary Mathematics Education: Insights from Future Teachers' Portfolios

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Abstract: The integration of digital technology in education has become an essential competency for primary school teachers, particularly in mathematics education, where innovative tools can enhance learning outcomes and student engagement. This paper investigates the extent and nature of digital technology utilization among future mathematics teachers, focusing on tools like dynamic geometry software (GeoGebra), e-testing platforms (e.g., Kahoot), learning applications (e.g., Learning Apps), and immersive technologies such as augmented and virtual reality. Our research centers on the analysis of final portfolios submitted by graduating students from the Faculty of Education at the University of Ostrava in 2024. These portfolios, which are a culmination of the students' educational strategies and experiences, offer a unique lens through which to assess the preparedness and innovation potential of future educators. Additionally, we surveyed the views of these students through questionnaires on the use of digital technologies in mathematics teaching. We specifically examined how these candidates plan to integrate digital technologies into their teaching practices and the innovative methods they propose to engage primary school students in mathematics. Through a qualitative study of 24 portfolios and a questionnaire survey of 15 students, we identified prevalent trends and inventive approaches in the use of digital tools. Our analysis highlights not only the variety of digital technologies incorporated into teaching strategies but also the depth of pedagogical integration, reflecting a sophisticated understanding of how to enhance learning environments effectively. The findings underscore the importance of digital literacy in teacher education and suggest that current training programs are effective in equipping future educators with the necessary skills to implement advanced technological tools. This study contributes to the ongoing discussion about digital competence in education, providing evidence of emerging trends and the transformative potential of digital technologies in primary mathematics education.

Keywords: Digital technologies, Mathematics education, Teacher education, Student engagement, Digital literacy

1. Introduction

The integration of digital technologies into education has increasingly become a focal point for modern teaching practices, particularly in mathematics education. As educational paradigms shift towards more interactive and student-centered learning environments, the role of digital tools in facilitating these changes cannot be overstated. Digital technologies such as dynamic geometry software, online testing platforms, and interactive learning applications have shown great potential in enhancing both learning outcomes and student engagement.

Future mathematics teachers are now being trained in an era where digital literacy is as crucial as traditional pedagogical skills. At the Faculty of Education at the University of Ostrava, teacher education programs are designed to equip future educators with the necessary skills to integrate digital technologies effectively into their teaching practices. The curriculum includes comprehensive training in various digital tools such as GeoGebra for dynamic geometry, Kahoot for interactive assessments, and Learning Apps for personalized learning experiences. Additionally, immersive technologies like augmented and virtual reality are also introduced to provide students with innovative ways to visualize and interact with mathematical concepts.

Digital technologies offer several advantages in the realm of mathematics education. They allow for the visualization of abstract concepts, making them more accessible and understandable for students. Tools like GeoGebra enable students to manipulate geometric figures dynamically, providing a deeper understanding of geometric properties and relationships. Online platforms like Kahoot facilitate real-time feedback and engagement through gamified learning experiences, which can significantly enhance motivation and participation.

Furthermore, digital tools support differentiated instruction, catering to the diverse needs of students. They provide opportunities for self-paced learning, where students can engage with content at their own speed, review difficult concepts, and practice problem-solving in a supportive environment. This flexibility is particularly beneficial in mathematics education, where students often need varying amounts of time and practice to master complex topics.

The research presented in this paper is situated within the context of the final portfolios submitted by graduating students from the Faculty of Education at the University of Ostrava in 2024. These portfolios are a culmination of the student's educational strategies, lesson plans, and reflections on their teaching practices. By analyzing these portfolios, this study aims to assess the extent and nature of digital technology utilization among future mathematics teachers.

Specifically, the research seeks to answer the following questions:

- What types of digital technologies do future mathematics teachers integrate into their lesson plans?
- What teaching methods are employed when using these digital technologies?
- What mathematical topics are taught using digital technologies?
- How do future mathematics teachers reflect and self-reflect on their teaching experiences with digital technologies?

Understanding how future mathematics teachers utilize digital technologies is critical for several reasons. Firstly, it provides insights into the current state of digital literacy and readiness among upcoming educators. Secondly, it highlights the innovative approaches and best practices that can be shared and implemented more broadly. Thirdly, it identifies potential challenges and areas for improvement, informing teacher education programs on how to better prepare future educators.

The findings of this study contribute to the ongoing discourse on digital competence in education. They provide evidence of emerging trends and the transformative potential of digital technologies in primary mathematics education. By documenting and analyzing the experiences and reflections of future teachers, this research offers valuable guidance for enhancing teacher education programs and ultimately improving student learning outcomes in mathematics.

2. Literature Review

The integration of digital technologies into mathematics education has garnered significant attention from researchers and educators alike. The ability of digital tools to enhance learning outcomes, increase student engagement, and support differentiated instruction has been well-documented. This literature review examines the current state of research on the use of digital technologies in mathematics education, focusing on the tools and methods that have proven effective, the challenges encountered, and the implications for teacher education.

Dynamic geometry software, such as GeoGebra, has been widely recognized for its ability to facilitate the visualization of geometric concepts. According to Hohenwarter and Fuchs (2004), GeoGebra allows students to manipulate geometric figures dynamically, providing a deeper understanding of geometric properties and relationships. Studies have shown that using such software can lead to improved spatial reasoning and problem-solving skills (Jones, 2000).

Online testing platforms like Kahoot have revolutionized the way assessments are conducted in the classroom. These platforms offer real-time feedback and engage students through gamified learning experiences. Wang (2015) found that the use of Kahoot in mathematics education significantly enhances student motivation and participation, leading to better retention of mathematical concepts.

Interactive learning applications, such as Learning Apps, provide personalized learning experiences that cater to the diverse needs of students. These applications support self-paced learning, allowing students to engage with content at their own speed and review difficult concepts as needed. Research by Kim and Chang (2010) highlights the effectiveness of interactive applications in improving mathematical performance and fostering a positive attitude towards learning.

Immersive technologies, including augmented reality (AR) and virtual reality (VR), offer innovative ways to visualize and interact with mathematical concepts. Dunleavy, Dede, and Mitchell (2009) note that AR and VR can create immersive learning environments that enhance conceptual understanding and engagement. These technologies are particularly effective in making abstract mathematical concepts more concrete and accessible.

The integration of digital technologies in teaching requires a shift in pedagogical strategies. Interactive methods, such as games and quizzes, have been shown to increase student engagement and understanding (Prensky, 2001). Collaborative methods, including group work facilitated by digital tools, promote active learning and peer interaction (Johnson & Johnson, 1999). Moreover, traditional direct instruction can be enhanced with digital tools to create a blended learning environment that supports varied learning styles (Means et al., 2010).

One of the primary challenges in integrating digital technologies is technical issues, such as connectivity problems and device malfunctions. These issues can disrupt the learning process and create frustration for both teachers and students (Ertmer & Ottenbreit-Leftwich, 2010). Ensuring reliable access to technology and providing robust technical support are essential to overcoming these challenges.

Varying levels of digital literacy among students and teachers can hinder the effective use of digital technologies. According to Voogt and Knezek (2008), targeted training is necessary to improve digital competencies. Teacher education programs should include comprehensive digital literacy training to ensure that educators are equipped to support their students effectively.

Teacher education programs must focus on developing both technical proficiency and pedagogical integration skills. As Koehler and Mishra (2009) suggest, effective integration of technology in teaching requires a combination of technological, pedagogical, and content knowledge (TPACK). Training programs should aim to balance these components to prepare future teachers adequately.

Providing opportunities for future teachers to experiment with various digital tools and reflect on their experiences is crucial. Reflective practice allows teachers to critically evaluate their use of technology and continuously improve their teaching strategies (Schon, 1983). Teacher education programs should facilitate such opportunities to foster a culture of continuous improvement.

Longitudinal studies examining the long-term impacts of digital technology integration on student learning outcomes and teacher development are needed. Such studies would provide a comprehensive understanding of the sustained effects of these tools and inform best practices in technology integration.

Comparative research exploring differences in digital technology use across various educational contexts, such as urban versus rural schools or different educational levels, can help identify specific needs and tailor support accordingly (Warschauer, Knobel, & Stone, 2004).

Further research is needed to investigate how digital technologies affect different groups of students, such as those with special educational needs or from diverse socio-economic backgrounds. Understanding these impacts would inform more inclusive and equitable teaching practices (Black & Wiliam, 1998).

The integration of digital technologies in mathematics education offers significant potential for enhancing learning outcomes and student engagement. However, challenges such as technical issues and digital literacy must be addressed to realize this potential fully. Teacher education programs play a critical role in preparing future educators to integrate digital tools effectively, emphasizing the need for balanced training in technological, pedagogical, and content knowledge. Future research should continue to explore the long-term impacts and contextual differences in digital technology use, contributing to a more comprehensive understanding of its role in education.

3. Research Design

This research employs a qualitative approach to understand how future mathematics teachers integrate digital technologies into their teaching practices. Qualitative research is chosen because it allows for a deep exploration of the experiences, practices, and reflections of the participants, providing rich, detailed data that can reveal insights into the complexities of teaching with digital technologies.

3.1 Methodology

The participants in this study are future mathematics teachers who have completed their teaching practice as part of their teacher education program at the Faculty of Education at the University of Ostrava. These individuals have created portfolios that document their lesson planning, teaching methods, the use of digital technologies, and their reflections on their teaching experiences. Data was collected from seven student portfolios.

These documents were chosen because they provide comprehensive information on the participants’ teaching practices, including lesson plans, descriptions of digital tools used, teaching methods, topics taught, and reflections on their teaching experiences (Merriam, 2009; Creswell, 2013).

Data Analysis

The data was analyzed using qualitative content analysis, which involves systematically coding and categorizing textual data to identify patterns, themes, and insights (Glaser & Strauss, 1967; Strauss & Corbin, 1998; Kostrub, 2016; Severini & Kostrub, 2018).

Open Coding

Open coding is the initial phase of the coding process, where the data is broken down into discrete parts and examined closely. The steps include:

1. Reading and Familiarization: Each portfolio was read thoroughly to understand the overall content and context.

2. Highlighting and Initial Coding: Relevant segments of text related to digital technologies, teaching methods, topics taught, and reflections were highlighted. Descriptive labels, or codes, were assigned to these segments to capture the essence of the information Strauss & Corbin, 1998; Kostrub, 2016).

3. Creating Initial Codes: A list of initial codes was developed based on the highlighted text. These codes were kept broad to encompass various aspects of the data (Merriam, 2009; Kostrub, 2016).

Axial Coding

Axial coding involves reassembling the data by finding connections between the codes identified during open coding. The steps include:

1. Grouping Similar Codes: The initial codes were grouped into categories that represent broader themes. This step helps in understanding how different codes relate to each other (Strauss & Corbin, 1998; Severini & Kostrub, 2018).

2. Developing Subcategories: Within each broad category, subcategories were created to provide more detailed insights. For example, under the category "Digital Technologies Used," subcategories such as "iPads," "Online Platforms," and "QR Codes" were developed (Merriam, 2009; Kostrub & Severini, 2018).

3. Refining Codes: The data was revisited to refine the codes and ensure that all relevant information was captured accurately. This iterative process helps in making the coding more precise and comprehensive (Creswell, 2013; Kostrub, 2016).

Themes and Categories

The analysis led to the identification of several key themes and categories:

1. Digital Technologies Used:
   - Types of technologies: iPads, online platforms (e.g., Kahoot, Wordwall), QR codes.
   - Purpose of technologies: enhancing student engagement, facilitating assessments, providing interactive learning experiences.
2. Teaching Methods:
   - Interactive methods: games, quizzes, interactive presentations.
   - Collaborative methods: group work, pair activities.
   - Direct instruction: traditional teaching methods supplemented by digital tools.
3. Mathematical Topics Taught:
   - Specific topics: fractions, angles, algebra, linear equations.
   - Integration with digital tools: how digital tools were used to teach these topics.
4. Reflections and Self-Reflections:
   - Positive outcomes: increased student engagement, improved understanding of concepts.
   - Challenges: technical issues, varying levels of digital literacy among students.
   - Suggestions for improvement: better planning, need for technical support, continuous training.

3.2 Conclusion

This study offers a detailed exploration into the integration of digital technologies by future mathematics teachers, providing insights into their lesson planning, teaching methods, topics covered, and reflective practices. The findings from the analysis of seven student portfolios reveal several key themes and offer significant implications for teacher education programs.

Summary of Findings

The analysis identified several key insights into how future mathematics teachers utilize digital technologies:

1. Digital Technologies Used:

- Types of Technologies: The portfolios demonstrated a wide range of digital tools such as iPads, online platforms like Kahoot and Wordwall, and QR codes. These tools were employed for different purposes, including engaging students, facilitating assessments, and providing interactive learning experiences.

2. Teaching Methods:

- Interactive Methods: Many teachers incorporated interactive methods like games, quizzes, and interactive presentations to enhance student engagement and understanding.
- Collaborative Methods: Group work and pair activities were commonly used, leveraging digital tools to facilitate collaboration among students.
- Direct Instruction: Traditional teaching methods were supplemented with digital tools to create a blended learning environment.

3. Mathematical Topics Taught:

- Specific Topics: The use of digital technologies was applied across various mathematical topics such as fractions, angles, algebra, and linear equations. These tools helped make abstract concepts more concrete and accessible through visual and interactive representations.

4. Reflections and Self-Reflections:

- Positive Outcomes: The use of digital technologies generally led to increased student engagement and improved understanding of mathematical concepts. The interactive nature of these tools helped maintain student interest and motivation.
- Challenges Faced: Technical issues were a common challenge, including connectivity problems and device malfunctions. Additionally, varying levels of digital literacy among students posed difficulties for some teachers.
- Suggestions for Improvement: Reflections included valuable suggestions for future practice, such as better planning for technical contingencies, the need for more comprehensive digital literacy training for both teachers and students and continuous professional development.

Implications for Teacher Education

The findings have important implications for the design and implementation of teacher education programs. These programs should focus on the following areas:

1. Technical Proficiency and Pedagogical Integration:

- Teacher education programs must ensure that future teachers are not only technically proficient in using digital tools but also skilled in integrating these tools into their pedagogical practices effectively. This dual focus will enable teachers to create engaging and effective learning environments.

2. Opportunities for Practice and Reflection:

- Providing opportunities for future teachers to experiment with various digital tools and reflect on their experiences is crucial. Reflective practice allows teachers to critically evaluate their use of technology and continuously improve their teaching strategies.

3. Support for Digital Literacy:

- Given the challenges related to digital literacy, teacher education programs should include comprehensive training on digital skills. This training should address both the technical and pedagogical aspects of digital tool use, ensuring that teachers can support their students effectively.

Addressing Challenges

The study highlights several challenges that need to be addressed to enhance the integration of digital technologies in teaching:

1. Technical Support:

- Schools and teacher education programs must ensure reliable access to technology and provide robust technical support to teachers. This support can help mitigate issues related to device malfunctions and connectivity problems.

2. Digital Literacy Development:

- Both teachers and students need targeted training to improve their digital literacy. Teacher education programs should offer courses and workshops focused on developing these skills, ensuring that all participants are comfortable and proficient with the required technologies.

3. Time Management and Classroom Management:

- Effective time management is essential when integrating digital tools into lessons. Future teachers should be trained in classroom management strategies that allow for the seamless incorporation of technology without disrupting the lesson flow. Providing practical tips and best practices can help teachers manage their time more effectively.

Future Research Directions

While this study provides valuable insights, several areas warrant further investigation:

1. Longitudinal Studies:

- Longitudinal studies could examine the long-term impacts of digital technology integration on student learning outcomes and teacher development. Such studies would provide a more comprehensive understanding of the sustained effects of these tools.

2. Comparative Studies:

- Comparative research could explore differences in digital technology use across various educational contexts, such as urban versus rural schools or different educational levels. This would help identify specific needs and tailor support accordingly.

3. Impact on Diverse Student Groups:

- Further research could investigate how digital technologies affect different groups of students, such as those with special educational needs or from diverse socio-economic backgrounds. Understanding these impacts would inform more inclusive and equitable teaching practices.

In conclusion, this study underscores the potential of digital technologies to transform mathematics education when effectively integrated into teaching practices. By addressing the challenges identified and leveraging the benefits of these technologies, future mathematics teachers can create dynamic and engaging learning environments that enhance student understanding and motivation. Teacher education programs play a critical role in preparing future teachers for this task, ensuring they are equipped with the necessary skills and knowledge to thrive in a digital age. Through comprehensive training and support, we can foster a new generation of educators who are adept at using digital tools to enrich their teaching and improve student learning outcomes.

4. Survey. Questionary

4.1 Survey

As part of a questionnaire survey, we compared the experience of using digital technologies in the teaching of mathematics between students of the 1st and 2nd year of the follow-up master's program Teaching for the 2nd grade of elementary school - combination with mathematics. We investigated the experiences of these students with digital technologies at primary and secondary schools, then during their studies at higher education institutions, during practical experience at higher education institutions and whether they would like to use digital technologies as part of their work as mathematics teachers at primary schools.

15 students took part in the research, including 8 second-year students and 7 first-year students. Women slightly predominate: 9 women and 6 men. Regarding the secondary school completed, among the students there are only 3 students who graduated from the gymnasium, 11 students graduated from the vocational secondary school and 1 student is a graduate of the vocational secondary school in the field with a high school diploma.

4.2 Analysis of the Questionnaire

From the questionnaire survey, we found that among the 4th and 5th grade students, the majority (40%) stated that they had never encountered the use of digital technologies in teaching mathematics during their studies at primary or secondary school, even 2/3 had never or almost never encountered it. Only 1 student stated that he encountered the use of digital technologies often.

Of the 11 students, approximately 36% reported that digital technologies were more likely to help them in their learning, a similar proportion of students said that digital technologies were more likely not to help them, and the remaining number was in the middle on a Likert scale.

Of the 15 students, approximately 88% confirmed the use of digital technologies at the university within the mathematics courses. Only one student stated that she hardly used digital technologies while studying mathematics at the university.

Regarding the use of digital technologies in the completed internships, out of 15 students, only two students did not encounter the use of digital technologies in the teaching of mathematics during their listening experience. 9 of the interviewed students took part in teaching as part of their practice, 6 of them stated that they often or occasionally used digital technologies in their practice, 3 students used digital technologies on average.

All 14 students who answered the above question confirmed that they want to use digital technologies in their mathematics education. They most often mentioned an interactive whiteboard or panel, and tablets. From the applications, GeoGebra, Kahoot, and Blooket. TEAMs, Nearpod, Geoboard online, Wordwall, Únikovka, Pattern Shapes applications appeared among others.

The conducted questionnaire survey revealed that although students encountered digital technologies minimally during their studies at primary and secondary schools, at universities they were already exposed to digital technologies much more in preparation for their profession. Students rarely used digital technologies during their internships, which, after discussion with them, mostly resulted in limited opportunities for use in primary schools. Mostly it was a limited number of tablets and limited access to computer labs. Nevertheless, they mostly want to improve this situation in the future and include digital technologies in the teaching of mathematics at elementary schools to a greater extent so that it is beneficial and not counterproductive.

4.3 Method of Statistical Processing

In the frame of the quantitative research, the statistical method (Stockemer, 2019) of multidimensional regression analysis has been selected with regard to the focus of the proposed analysis. The dependent and independent variables have been determined for further clarification, of whether statistically significant interactions have appeared.

Hypotheses. Based on the goal and tasks of the contribution, we created hypotheses, which we approach in the results of the work.

Hypotheses Proposal

The following items were considered in the frame of the quantitative research (Table 1):

Table 1: Description of Questions' Variables

Question Code	Description
Q9	Efficiency
Q1	Gender
Q3	Using digital technologies at Elementary or Middle School
Q5	Using digital technologies at the University
Q7	Using digital technologies at practices with students
Q12	Future implementation of digital technologies in teacher job

The following hypotheses were proposed and tested in the software PAST Statistics (Hammer, 2001) as the multi-regression approach.

H_0: There is not statistically significant interaction between item Q9 and {Q1, Q3, Q5, Q7, Q12} on the significance level.

H_A: There are statistically significant interactions between item Q9 and {Q1, Q3, Q5, Q7, Q12} on the significance level.

H_0-Q1: There are no statistically significant interactions between items Q9 and Q1 on the significance level.

H_A-Q1: There are statistically significant interactions between items Q9 and Q1 on the significance level.

H_0-Q3: There are no statistically significant interactions between items Q9 and Q3 on the significance level.

H_A-Q3: There are statistically significant interactions between items Q9 and Q3 on the significance level.

H_0-Q5: There are no statistically significant interactions between items Q9 and Q5 on the significance level.

H_A-Q5: There are statistically significant interactions between items Q9 and Q5 on the significance level.

H_0-Q7: There are no statistically significant interactions between items Q9 and Q7 on the significance level.

H_A-Q7: There are statistically significant interactions between items Q9 and Q7 on the significance level.

H_0-Q12: There are no statistically significant interactions between items Q9 and Q12 on the significance level.

H_A-Q12: There are statistically significant interactions between items Q9 and Q12 on the significance level.

Results of Testing Hypotheses

Sample size N is equal to 15 with non-parametrical behavior tested using the Shapiro-Wilk method.

The multidimensional regression analysis (Table 2) is bounded on the principle of p values with complementation of effect sizes supporting a case of rejecting a zero hypothesis in favor of an alternative hypothesis. Results of occurred p values are being corresponded as: $p < .001$, $p < .01$, $p < .05$. Across the independent variables, the nominal and cardinal types of variables have appeared. For each independent variable, the influence of each independent variable is denoted also using by p-value. The following effect sizes are considered as the Cohens' f: small > .02, moderate > .15 and large > .35; as the r: small < .3, medium from .3 to .5, large > .5 An adjusted multiple R^2 has been strengthened by consideration of the size of sample size inside the computations.

Table 2: Obtained Results of Multi-Regression Dependences Analyses

Related Hypothesis	
y Dependent Variable of Model	Q9
H: *p*-value for Multiregression	**1**
Effect Size Cohen's f^2	**Non**
Adjusted Multiple R^2	-461.720
Independent Variable	
H-Q1:	.959
H-Q3:	.975
H-Q5:	.981
H-Q7:	.958
H-Q12:	1.000

$p < .001$, $p < .01$, $p < .05$

Conclusion of Testing Hypotheses

According to Table 2, the statistically significant influence on the variable Q3(Efficiency) doesn't have variables Q1, Q3, Q5, Q7, and Q12.

> *H_0: There is not statistically significant interaction between item Q9 and {Q1, Q3, Q5, Q7, Q12} on the significance level.*
>
> *H_0-Q1: There are no statistically significant interactions between items Q9 and Q1 on the significance level.*
>
> *H_0-Q3: There are no statistically significant interactions between items Q9 and Q3 on the significance level.*
>
> *H_0-Q5: There are no statistically significant interactions between items Q9 and Q5 on the significance level.*
>
> *H_0-Q7: There are no statistically significant interactions between items Q9 and Q7 on the significance level.*
>
> *H_0-Q12: There are no statistically significant interactions between items Q9 and Q12 on the significance level.*

5. Conclusion and Discussion

5.1 Summary of Results

This study explored the integration of digital technologies in mathematics education among future mathematics teachers, using a combination of qualitative and quantitative research methods. The qualitative analysis of seven student portfolios and the quantitative questionnaire survey of 15 students provided comprehensive insights into the use of digital tools in teaching practices.

Qualitative Findings:

1. Digital Technologies Used:

- Future mathematics teachers employed a variety of digital tools, including iPads, online platforms like Kahoot and Wordwall, and QR codes.
- These tools were used for enhancing student engagement, facilitating assessments, and providing interactive learning experiences.

2. Teaching Methods:

- Interactive methods (e.g., games, quizzes, interactive presentations) were commonly used to boost student engagement and understanding.

- Collaborative methods (e.g., group work, pair activities) facilitated by digital tools promoted active learning and peer interaction.
- Direct instruction was often supplemented with digital tools, creating a blended learning environment.

3. Mathematical Topics Taught:

- Digital technologies were applied to various mathematical topics, including fractions, angles, algebra, and linear equations.
- These tools helped make abstract concepts more concrete and accessible through visual and interactive representations.

4. Reflections and Self-Reflections:

- Positive outcomes included increased student engagement and improved understanding of mathematical concepts.
- Challenges included technical issues and varying levels of digital literacy among students.
- Suggestions for improvement focused on better planning, technical support, and continuous training.

Quantitative Findings:

1. Exposure to Digital Technologies:

- The majority of students had minimal exposure to digital technologies during their primary and secondary education. However, at the university level, they experienced a significant increase in the use of digital tools in their training.

2. Current Use of Digital Technologies:

- During internships, the use of digital technologies varied, with most students encountering limited opportunities due to resource constraints in primary schools.

3. Future Intentions:

- All surveyed students expressed a desire to use digital technologies in their future teaching practices, highlighting tools like interactive whiteboards, tablets, and applications such as GeoGebra, Kahoot, and Nearpod.

5.2 Statistical Analysis

The multidimensional regression analysis revealed no statistically significant interactions between the efficiency of digital technologies (Q9) and the variables Q1 (gender), Q3 (use of digital technologies in primary/secondary school), Q5 (use of digital technologies at the university), Q7 (use of digital technologies during internships), and Q12 (future implementation of digital technologies).

Comparison with Literature Review

The findings from this study align with existing literature on the use of digital technologies in mathematics education. According to the literature review:

1. Enhanced Learning Outcomes and Engagement:

- Tools like GeoGebra facilitate the visualization of geometric concepts, leading to improved spatial reasoning and problem-solving skills (Hohenwarter & Fuchs, 2004; Jones, 2000). Similarly, our study found that digital tools helped make abstract concepts more concrete and accessible.

2. Gamified Learning Experiences:

- Platforms like Kahoot provide real-time feedback and engage students through gamified learning experiences, significantly enhancing motivation and participation (Wang, 2015). The use of interactive methods in our study, such as quizzes and games, echoed these benefits.

3. Personalized Learning:

- Interactive applications like Learning Apps support self-paced learning and improve mathematical performance (Kim & Chang, 2010). Our findings also highlighted the role of digital tools in providing interactive learning experiences and facilitating differentiated instruction.

4. Challenges:

- Technical issues and varying levels of digital literacy are common challenges (Ertmer & Ottenbreit-Leftwich, 2010; Voogt & Knezek, 2008). These challenges were also evident in our study, emphasizing the need for robust technical support and comprehensive digital literacy training.

Implications for Teacher Education

The study underscores the need for teacher education programs to focus on both technical proficiency and pedagogical integration of digital tools. Key recommendations include:

1. Comprehensive Training:

- Teacher education programs should provide extensive training on the use of digital tools, ensuring that future educators are proficient in both the technical and pedagogical aspects.

2. Opportunities for Practice and Reflection:

- Programs should offer opportunities for future teachers to experiment with digital tools and reflect on their experiences, fostering a culture of continuous improvement.

3. Support for Digital Literacy:

- Targeted training to improve digital literacy among both teachers and students is essential to overcome the challenges related to varying levels of digital skills.

Future Research Directions

To build on these findings, future research should explore:

1. Longitudinal Studies:

- Investigating the long-term impacts of digital technology integration on student learning outcomes and teacher development.

2. Comparative Studies:

- Examining differences in digital technology use across various educational contexts, such as urban versus rural schools or different educational levels.

3. Impact on Diverse Student Groups:

- Studying how digital technologies affect different groups of students, including those with special educational needs or from diverse socio-economic backgrounds, to inform more inclusive and equitable teaching practices.

Limitations of the Study

Despite the valuable insights provided by this study, there are several limitations that need to be acknowledged:

1. Sample Size:

- The study involved a small number of participants (seven portfolios analyzed qualitatively and 15 students surveyed quantitatively). This limited sample size may not fully represent the broader population of future mathematics teachers and may affect the generalizability of the findings.

2. Self-Reported Data:

- The data collected through portfolios and questionnaires relied on self-reported information, which could be subject to biases such as social desirability or recall bias.

3. Contextual Factors:

- The study was conducted within a specific educational context (the Faculty of Education at the University of Ostrava), which may limit the applicability of the findings to other settings with different resources, curricula, and student demographics.

4. Technical and Logistical Constraints:

- The study highlighted challenges related to limited access to digital resources during internships. These constraints may have influenced the extent to which participants could experiment with and reflect on the use of digital technologies.

In conclusion, this study highlights the transformative potential of digital technologies in primary mathematics education. By addressing the challenges identified and leveraging the benefits of these tools, future mathematics teachers can create dynamic and engaging learning environments that enhance student understanding and motivation. Teacher education programs play a critical role in preparing educators for this task, ensuring they are equipped with the necessary skills and knowledge to thrive in a digital age. Through comprehensive training and support, we can foster a new generation of educators who are adept at using digital tools to enrich their teaching and improve student learning outcomes.

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